Eur. Phys. J. A (2014) **50**: 127
DOI 10.1140/epja/i2014-14127-5

THE EUROPEAN
PHYSICAL JOURNAL A

Regular Article – Theoretical Physics

Form factors and decay rate of $B_c^* \to D_s\ l^+l^-$ decays in the QCD sum rules

K. Zeynali[1,a], V. Bashiry[2,b], and F. Zolfagharpour[3,c]

[1] Department of Sciences, Faculty of Medicine, Ardabil University of Medical Sciences, Ardabil, Iran
[2] Cyprus International University, Faculty of Engineering, Nicosia, Northern Cyprus, Mersin 10, Turkey
[3] Department of Physics, University of Mohaghegh Ardabili, PO Box 179, Ardabil, Iran

Received: 20 April 2014 / Revised: 23 June 2014
Published online: 15 August 2014 –
Communicated by Xin-Nian Wang

Abstract. Rare exclusive $B_c^* \to D_s\ l^+l^-$ decays are analyzed in the framework of the three-point QCD sum rules approach. The two-gluon condensate corrections to the correlation function are included and the form factors of this transition are evaluated. Using the form factors, the decay width and integrated decay rate for these decays are also calculated.

1 Introduction

The rare flavor-changing neutral-current (FCNC) processes $\{b \to s(d)\}$ are widely studied to test the predictions of Standard Model (SM) at loop level and to search for new physics (NP). The recent theoretical studies can be found in refs. [1–6].

Various physical observables of leptonic, semileptonic and radiative B decays have been measured by LHCb. For instance, the form factor, independent observables in the decay $B^0 \to K^{*0}\mu^+\mu^-$ [7] and the the CP asymmetry in $B^+ \to K^+\mu^+\mu^-$ decays [8] have been measured. More recent measurements in the LHCb for FCNC transitions can be seen in refs. [9–11]. Measurements of various observables at LHCb indicate that SM predictions are in good agreement with the experimental results. Therefore, most of the new physics scenarios are excluded.

Rare $B_c^* \to D_s\ l^+l^-$ proceeds FCNC transitions. This decay has not yet been measured by LHCb. There are not theoretical studies relevant to the form factors and decay rate of this decay. We try to calculate the form factors and the decay rate of the $B_c^* \to D_s\ l^+l^-$ decay as well. We use the three-point QCD sum rules approach in the calculation of these form factors. The QCD sum rules have been widely used to calculate form factors (some similar studies can be found in refs. [12–19]).

The paper includes 3 sections: In sect. 2, we recall the effective Hamiltonian and use the three–point QCD sum rules approach to calculate these form factors. In sect. 3, we will use the numerical values of form factors in order to determine the sensitivity of the decay rate to the invariant dileptonic mass and then present our conclusion.

[a] e-mail: `k.zeinali@arums.ac.ir`
[b] e-mail: `bahiry@ciu.edu.tr`
[c] e-mail: `zolfagharpour@uma.ac.ir`

2 Sum rules for the $B_c^* \to D_s\ l^+l^-$ transition form factors

The matrix element of the $b \to s\ell^+\ell^-$ transition can be written as

$$M(b \to s\ell^+\ell^-) = \frac{G_F\alpha}{\sqrt{2}\pi} V_{tb}V_{ts}^* \times \left\{ c_9^{\rm eff}\mathcal{O}_9 + c_{10}\mathcal{O}_{10} - 2\frac{m_b}{q^2}c_7^{\rm eff}\mathcal{O}_7 \right\}, \tag{1}$$

where

$$\mathcal{O}_7 = \frac{1}{2}\left[\bar{s}i\sigma_{\mu\nu}q^\nu(1+\gamma_5)b\right]\left[\bar{\ell}\gamma^\mu\ell\right],$$

$$\mathcal{O}_9 = \frac{1}{2}\left[\bar{s}\gamma_\mu(1-\gamma_5)b\right]\left[\bar{\ell}\gamma^\mu\ell\right],$$

$$\mathcal{O}_{10} = \frac{1}{2}\left[\bar{s}\gamma_\mu(1-\gamma_5)b\right]\left[\bar{\ell}\gamma^\mu\gamma^5\ell\right],$$

and c_7, c_9 and c_{10} are Wilson coefficients evaluated in the naive dimensional regularization (NDR) scheme at the leading order (LO), next-to-leading order (NLO) and next-to-next-to-leading order (NNLO) in the SM [20–27].